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REPRODUCTION AND FOOD HABITS OF SEVEN SPECIES OF NORTHERN GULF OF MEXICO FISHES

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ABSTRACT

Sex ratios, length-weight relationships, maturation, fecundity, and food habits were determined from 7,400 individuals of seven species of inner continental shelf fishes. Samples were taken from trawl catches at depths of 9–91 m between Pensacola Bay, Florida and Brownsville, Texas and from the Campeche Bank, Mexico during the period October 1980–June 1982. Sex ratios favored males in silver seatrout, *Cynoscion nothus*, and Atlantic cutlassfish, *Trichiurus lepturus*, favored females in Atlantic croaker, *Micropogonias undulatus*, hardhead catfish, *Arius felis*, and longspine porgy, *Stenotomus caprinus*, but were equal in sand seatrout, *C. arenarius*, and spot, *Leiostomus xanthurus*. Peak gonadal development was found during spring in longspine porgy, summer in hardhead catfish, spring and late summer in sand and silver seatrouts, spring through fall in Atlantic cutlassfish, and fall in spot and Atlantic croaker. The first Gulf of Mexico fecundity data for six of these species (second record for hardhead catfish) indicated the following maximum fecundities: hardhead catfish—104 eggs; Atlantic cutlassfish—42,100; longspine porgy—43,100; silver seatrout—389,500; sand seatrout—423,100; spot—514,400; and Atlantic croaker—1,075,000. Food habits on either side of the Mississippi Delta were related to age, location, and time of capture. Atlantic cutlassfish were piscivorous. Sand and silver seatrouts preyed on a mixture of fishes and shrimps, and although sand seatrout diets did not vary with age and location, silver seatrout diets did. The remaining species were benthic feeders. Spot fed primarily on polychaetes and detrital matter and secondarily on crustaceans. There were distinct differences in feeding habits of spot between day and night: during the day they ate epifauna, whereas at night they consumed infaunal polychaetes. Atlantic croaker and hardhead catfish diets were dependent upon age: young fish ate polychaetes and older fish preyed upon large, mobile epifauna such as crabs, fishes, shrimps, and stomatopods. Hardhead catfish from the East Delta consumed more polychaetes and less fish and shrimp than did fish from the West Delta. Longspine porgy of all ages consumed mainly polychaetes and detritus both day and night but preyed more upon epifauna in West Delta waters.

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INTRODUCTION

Bottomfish stocks in the northern Gulf of Mexico comprise some 200 species, excluding reef fishes, captured out to 100 m depths (Hoese and Moore 1977). Commercial and recreational fisheries yield about 60,000 metric tons/year, while an estimated 300,000 metric tons/year are discarded by commercial shrimp fleets (Gulf of Mexico Fishery Management Council 1980). The highest densities of bottomfishes are found around the Mississippi Delta, and it is there that the fishery is centered. Although a large number of species are caught, seven average 75% by weight of catches on the Delta fishing grounds (Gutherz 1981) and 45–75% off the Texas coast (Chittenden and McEachran 1976). In order of decreasing weight composition, these fishes are Atlantic croaker, *Micropogonias undulatus*; spot, *Leiostomus xanthurus*; longspine porgy, *Stenotomus caprinus*; hardhead catfish, *Arius felis*; sand seatrout, *Cynoscion arenarius*; silver seatrout, *C. nothus*; and Atlantic cutlassfish, *Trichiurus lepturus*. The distributions and abundances of these species have been delimited between Pensacola, Florida and Brownsville, Texas (Roithmayer 1965; Moore, Brusher, and Trent 1970; Gutherz, Russell, Serra, and Rohr 1975; Chittenden and McEachran 1976; Ragan, Melancon, Harris, Falgout, Gann, and Green 1978).

Despite their abundance and commercial importance, research on maturation, reproduction, and feeding of these seven species in offshore waters has been minimal (Gulf of Mexico Fishery Management Council 1980). However, Texas researchers have recently examined the population dynamics and life histories of sand seatrout (Shlossman and Chittenden 1981), silver seatrout (DeVries and Chittenden 1982), and longspine porgy (Geoghegan and Chittenden 1982). In this report, we describe sex ratios, maturation, spawning, fecundity, length-weight relationships, and foods of the seven dominant bottomfishes in the northern Gulf of Mexico.

MATERIALS AND METHODS

Fishes were taken from SEAMAP (Southeast Area Monitoring and Assessment Program) trawl catches made by the NOAA RV *OREGON II*, the Texas Parks and Wildlife Department RV *WESTERN GULF*, and the contract vessel *JEFF AND TINA* primarily between Pensacola Bay, Florida and Brownsville, Texas in 9–91 m waters. Day and night collections were made around the Mississippi Delta (Louisiana to western Florida), and nocturnal collections were made off Texas and the Campeche Bank, Mexico between October 1980 and June 1982 (Table 1). Each vessel towed a 12.2 m semiballoon trawl with tickler chain at 5–6 km/hr. Fishes were collected according to 1) arbitrary depth strate (9–17 m, 18–36 m, 37–55 m, 56–73 m, and 74–91 m), 2) East Delta (87°20′–89°30′ W longitude), West Delta (89°30′–94° W), Texas, or Mexico, and 3) day or night capture. Specimens were preserved in 3.7% formaldehyde-seawater or frozen until analyzed. We present diets only from the East and West Delta areas since foods off the Texas coast have been discussed by Sheridan and Trimm (1983).

Fish were measured to the nearest millimeter standard length (SL) except for Atlantic cutlassfish that were measured in total length (TL). All were weighed to the nearest 0.1 gram after blotting them dry. Length-weight relationships were determined by regression of log-transformed data. Fishes were presumed to have reached a given age at the following lengths: longspine porgy, Age I = 75 mm, Age II = 125 mm (Geoghegan and Chittenden 1982); spot, Age

TABLE 1

Numbers of bottomfishes collected for reproductive and food analyses by coastal area. Mississippi Delta divided into East (87°20′–89°30′W longitude) and West (89°30′–94°00′W longitude). Mexico collections from 19°30′N latitude, 91°30′W longitude.

	Area				
Species	East Delta	West Delta	Texas	Mexico	Total
Sand seatrout	355	597	233	6	1,191
Silver seatrout	181	474	133	-	788
Spot	309	563	206	-	1,078
Atlantic croaker	376	693	312	15	1,396
Hardhead catfish	138	465	49	7	659
Longspine porgy	532	567	327	-	1,426
Atlantic cutlassfish	320	475	58	-	853
Total	2,211	3,834	1,318	28	7,391
Collection months	11/80, 4/81	10/80,4/81	6/81	3/81	
	10/81, 3/82	6-10/81	7/81		
	6/82	3/82, 6/82	6/82		

I = 125 mm, Age II = 160 mm, Age III = 175 mm (Pearson 1928; Townsend 1956; Sundararaj 1960); Atlantic croaker, Age I = 125 mm, Age II = 200 mm, Age III = 250 mm (Roithmayer 1965; Parker 1971; White and Chittenden 1977; Warren, Perry and Boyes 1978; Gulf of Mexico Fishery Management Council 1980); hardhead catfish, Age I = 150 mm (Lee 1937; Christmas and Waller 1973); sand seatrout, Age I = 150 mm (Shlossman and Chittenden 1981); silver seatrout, Age I = 150 mm (Warren *et al.* 1978; DeVries and Chittenden 1982); Atlantic cutlassfish, Age I = 400 mm, Age II = 700 mm (Dawson 1967). Stomachs were stored in 40% isopropanol. Gonads were examined visually and assigned to one of six maturation stages (undeveloped, immature, developing, maturing, ripe, or spent, after Rohr and Gutherz 1977). All were weighed to the nearest 0.01 g after blotting except undeveloped and spent gonads and testes collected before July 1981. Maturing and ripe ovaries were stored in 40% isopropanol for fecundity estimates. Chi-square analysis was used to detect significant deviations from expected 1:1 sex ratios. A gonadal-somatic index (gonad weight as a percentage of total body weight) was computed for each fish to delimit potential spawning months for each species.

Fecundity was defined as the potential number of eggs that could be spawned over a reproductive season. For fecundity estimates, each pair of ovaries was removed from the preservative, blotted, and weighed to the nearest 0.01 g. Since hardhead catfish ovaries contained relatively few eggs, all yolked eggs were counted. For the other six species, a section was taken from the middle of the paired ovaries, weighed, and placed in water in a gridded petri dish. Eggs in the section were dispersed with forceps and yolked eggs were counted under a dissecting microscope. Section weights ranged between 0.05 and 0.50 g (larger sections contained larger eggs), yielding 400–4,000 eggs per section. Fecundity calculations assumed that eggs developed uniformly throughout the ovaries, all counted eggs would be released, and degeneration or resorption would be negligible. Fecundity was calculated by proportion:

$$\text{Fecundity} = \frac{(\text{eggs in subsample}) \text{ X } (\text{ovary weight}).}{\text{subsample weight}}$$

The relationships of fecundity to fish length, fish weight, and ovary weight were examined by regressions of untransformed and log transformed data, from which we present the best fits.

For each species each month, the stomach contents of all fish in a given age/area/time category were combined for all depths and were washed through sieves to separate similarly sized foods (Carr and Adams 1972). Contents of each sieve were identified microscopically, counted, washed into aluminum pans, and dried at 80–90°C for 24 hr. Dry weights of the foods were calculated from their numerical proportions in each sieve and converted to percentages of total stomach content dry weight. Stomach contents were identified to broad, but exclusive, categories such as sand, polychaetes, shrimps, or fishes. The rarely occurring algae, diatoms, seagrasses, seeds, and woody materials were grouped as plant matter. Fish bones and scales without associated flesh were often found in hardhead catfish stomachs and were given a category. Animal fragments not distinctly referable to any taxon were also categorized. Fine organic matter not referable to any other category was termed detritus. Animal fragments and detritus were tabulated separately from identifiable foods. Shrimps, crabs, and fishes were identified to family or genus, when possible, for qualitative analysis.

RESULTS AND DISCUSSION

MATURATION AND REPRODUCTION

Sand Seatrout

A total of 1,191 sand seatrout was weighed and measured. The relationship between length (SL) and weight (W) for fish 82–310 mm was:

$$\log_{10} W = 4.46 + 2.86 \log_{10} SL, \text{ where } r^2 = 0.99.$$

Thirty percent (355) of the fish were sexually undeveloped. The overall sex ratio was 436 males to 399 females or 1.09:1, which was not significantly different from a 1:1 ratio ($\chi^2 = 1.55, P > 0.20$). Sex ratios varied monthly but in no consistent pattern. Several investigations of sand seatrout have shown sex ratios favoring one sex over the other. Moffett, McEachron and Key (1979) examined 498 fish from Galveston Bay, Texas and found a male to female ratio of 1:1.66, while Landry and Armstrong (1980) reported a 1:1.32 ratio for 849 fish from western Louisiana. Off Freeport, Texas, however, the sex ratio was 1.30:1 in favor of males among 1,776 individuals (Shlossman and Chittenden 1981). In our samples, sexual identification was first possible for males at 84 mm and females at 82 mm. Smallest maturing fish were 129 and 140 mm for males and females, respectively. Shlossman and Chittenden (1981) found maturing fish at 146 mm and Gunter (1945) recorded a ripe 127-mm male.

Sexually undeveloped fish generally predominated in summer and fall samples (Fig. 1). Maturing and ripe individuals were mainly collected in March and April, although some were collected in August (females) and October (males). Shlossman and Chittenden (1981) postulated spawning from March through September with peaks in March–May and August–September off Freeport, Texas. Landry and Armstrong (1980) collected ripening females in winter off western Louisiana. The monthly variation we observed in gonadal-somatic indices indicated peaks in ovarian development in March–April and in August (Fig. 1) but only a March peak in testicular development, perhaps due to a small number of males sampled.

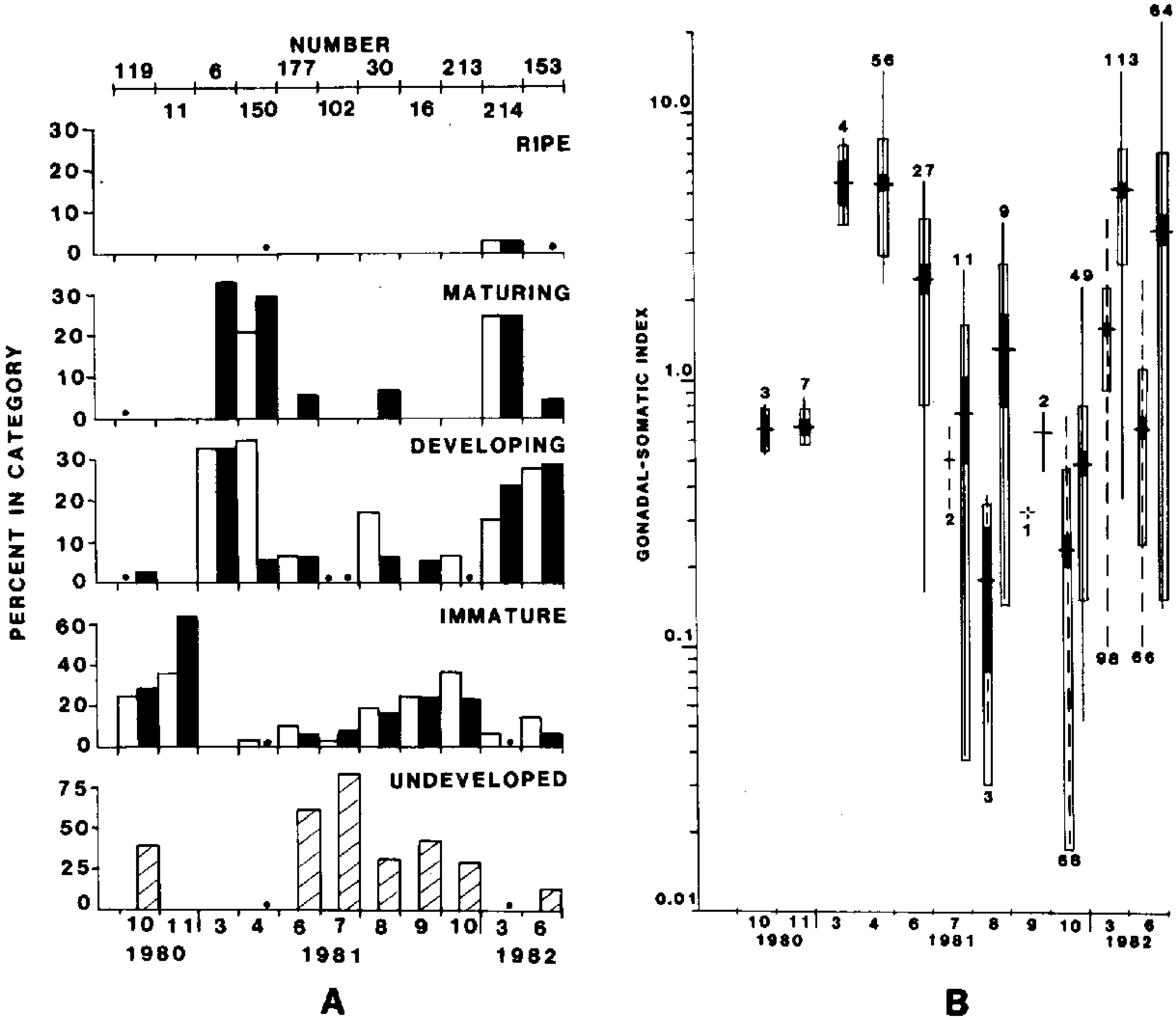

FIG. 1. Sand seatrout. (A) Monthly maturation stages. Open bar = male, black bar = female, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

There is little information concerning sand seatrout spawning habitat. Shlossman and Chittenden (1981) postulated spawning in 7–22 m waters and the lower reaches of estuaries. However, in months when we identified maturing and ripe females, these two sexual stages were relatively more abundant among fish collected from 56–73 m waters (17/45 fish = 38%) than among fish from other depth strata: 9–17 m, 41/294 fish = 14%; 18–36 m, 34/226 fish = 15%; 37–55 m, 32/131 fish = 24%; and 74–91 m, 7/34 fish = 21%. This contrast may be due to different habitats since Shlossman and Chittenden (1981) collected off Texas and our collections during the spawning season centered around the Mississippi Delta.

Fecundity was determined for 131 sand seatrout 140 to 278 mm *SL* (39.1 to 402.5 g). Fecundities ranged from 28,200 for a 210 mm (142.8 g) fish to

423,100 for 247 mm (365.9 g) fish from the Campeche Bank and 324,900 in a 224 mm (223.7 g) fish from the Mississippi Delta region. Fecundity (F) was only moderately related to fish length, fish weight, and ovary weight (OW):

$$F = -198{,}665 + 1{,}480\ SL, \text{ where } r^2 = 0.36;$$
$$F = -\ \ 8{,}917 + 759\ W, \text{ where } r^2 = 0.51; \text{ and}$$
$$F = 32{,}557 + 7{,}893\ OW, \text{ where } r^2 = 0.53.$$

Our data are apparently the first concerning fecundity of sand seatrout. Merriner (1976) reported that weakfish, *Cynoscion regalis*, from North Carolina have mean fecundities ranging from 44,900 at 145–160 mm to 1,725,900 at 395–480 mm. Sand seatrout are less fecund than weakfish of similar sizes: 140–278 mm sand seatrout averaged 100,900 eggs while 190–268 mm weakfish averaged 285,700 eggs.

Silver Seatrout

Seven hundred eighty-eight silver seatrout, 77–280 mm, were weighed. The relationship between length and weight was:

$$\log_{10} W = -4.63 + 2.94 \log_{10} SL, \text{ where } r^2 = 0.98.$$

Sexually undeveloped fish made up 24% (188) of the collection. The overall sex ratio was 328 males to 272 females or 1.21:1, which was significantly different from a 1:1 ratio ($\chi^2 = 5.04, P < 0.05$). Males were more abundant than females in all collections except July–September 1981 when the sex ratio was 1:1.47. Landry and Armstrong (1980) reported a sex ratio of 1:1.72 in spring and summer. We found sexual identification first possible at 77 mm for males and 80 mm for females. Smallest maturing silver seatrout were 140 mm. DeVries and Chittenden (1982) also reported ripe females as small as 140 mm, although Miller (1965) collected 110 mm ripe females.

Sexually undeveloped fish dominated the March–April and October collections (Fig. 2) but also occurred from spring through fall. Ripe females were found only in April and October 1981, but maturing females were collected over a longer period (March–April and August–October). Maturing males were found March through October. This extended maturity season was also reflected in the gonadal-somatic indices (Fig. 2) which showed little monthly variation. Our data suggest that the spawning season begins earlier than May, as proposed by DeVries and Chittenden (1982), and that spawning peaks occur early and late in the season.

Only 18 maturing and ripe female silver seatrout were collected. Their capture at various depths did not indicate a preferred spawning area. Fecundities for these fish, 140 mm (40.1 g) to 256 mm (291.5 g), ranged from 16,800 to 389,500 eggs. Fecundity was strongly related to fish length, fish weight, and ovary weight:

$$F = -362{,}882 + 2{,}570\ SL, \text{ where } r^2 = 0.76;$$
$$F = -\ \ 52{,}623 + 1{,}309\ W, \text{ where } r^2 = 0.84; \text{ and}$$
$$F = 32{,}539 + 5{,}662\ OW, \text{ where } r^2 = 0.94.$$

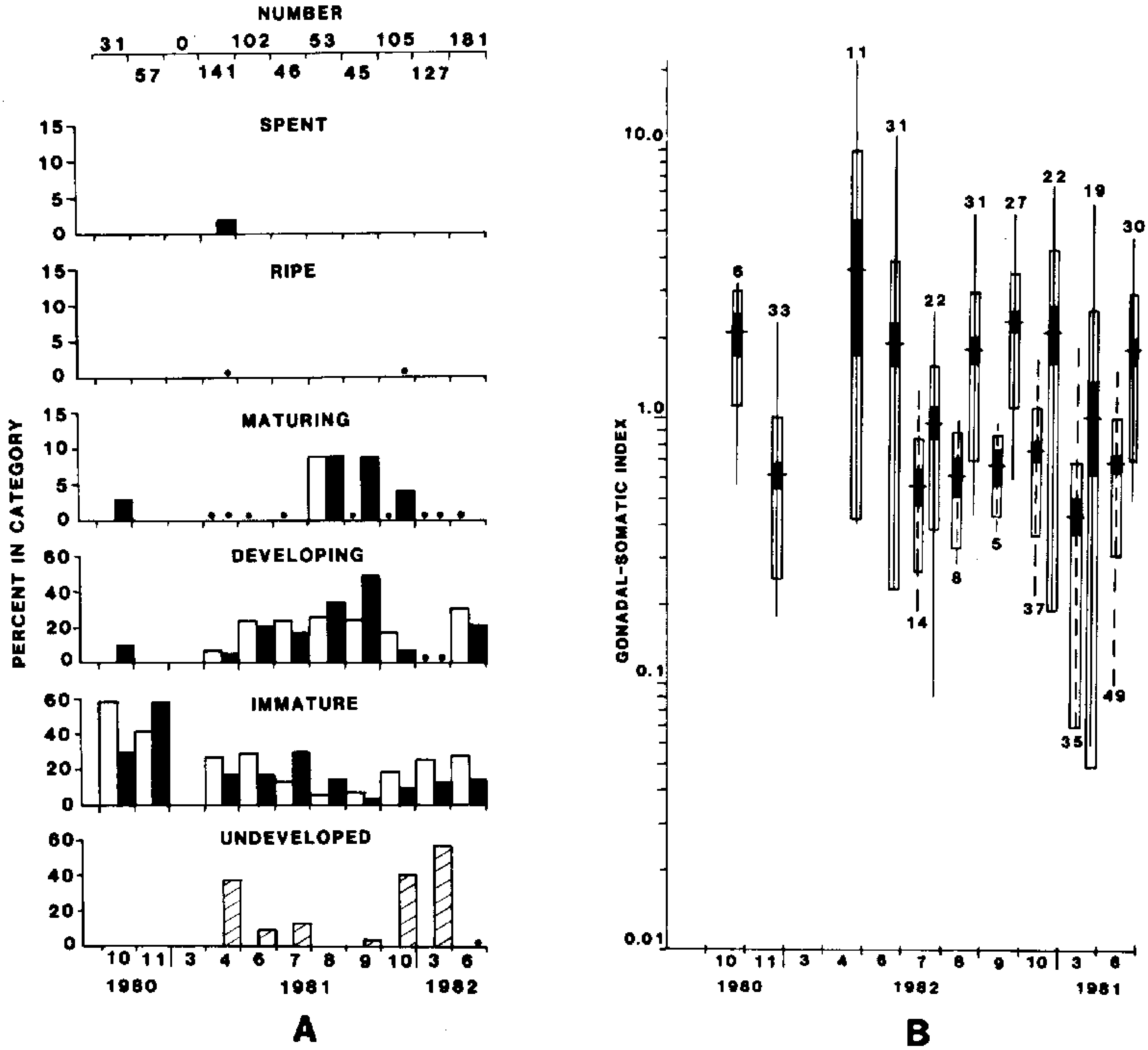

FIG. 2. Silver seatrout. (A) Monthly maturation stages. Open bar= males, black bar = females, shaded bar = undeveloped, dot = $\leq 2\%$ occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = $\pm$ 1 standard deviation, black rectangle = $\pm$ 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

Our data are apparently the first on fecundity of silver seatrout. Mean fecundity for these individuals was 73,900 eggs, compared to 100,900 eggs in 140–278 mm sand seatrout (this report) and 285,700 eggs in 190–268 mm weakfish (Merriner 1976).

Spot

A total of 1,078 spot, 63–147 mm, was weighed. Length and weight were related by the equation:

$$\log_{10} W = -4.44 + 2.95 \log_{10} SL, \text{ where } r^2 = 0.98.$$

Twenty-eight percent (299) of the fish were sexually undeveloped. The overall sex ratio was 399 males to 380 females or 1.05:1, which was not significantly different from 1:1 ($\chi^2 = 0.42, P > 0.50$). Pristas and Trent (1978) found 1:1 sex ratios in spring and summer but significantly more females during fall and winter in St. Andrew Bay, Florida. Sexual identification was first possible at 70 mm for males and 69 mm for females. Smallest maturing spot were 123 mm males and 127 mm for females. Pearson (1928) collected ripening female spot at 170 mm *TL* (= 130 mm *SL*, Sundararaj 1960).

Sexually undeveloped fish were most abundant in summer collections (Fig. 3). Maturing and ripe spot were collected only in October and November. Although a short fall spawning period is indicated, one ripe male

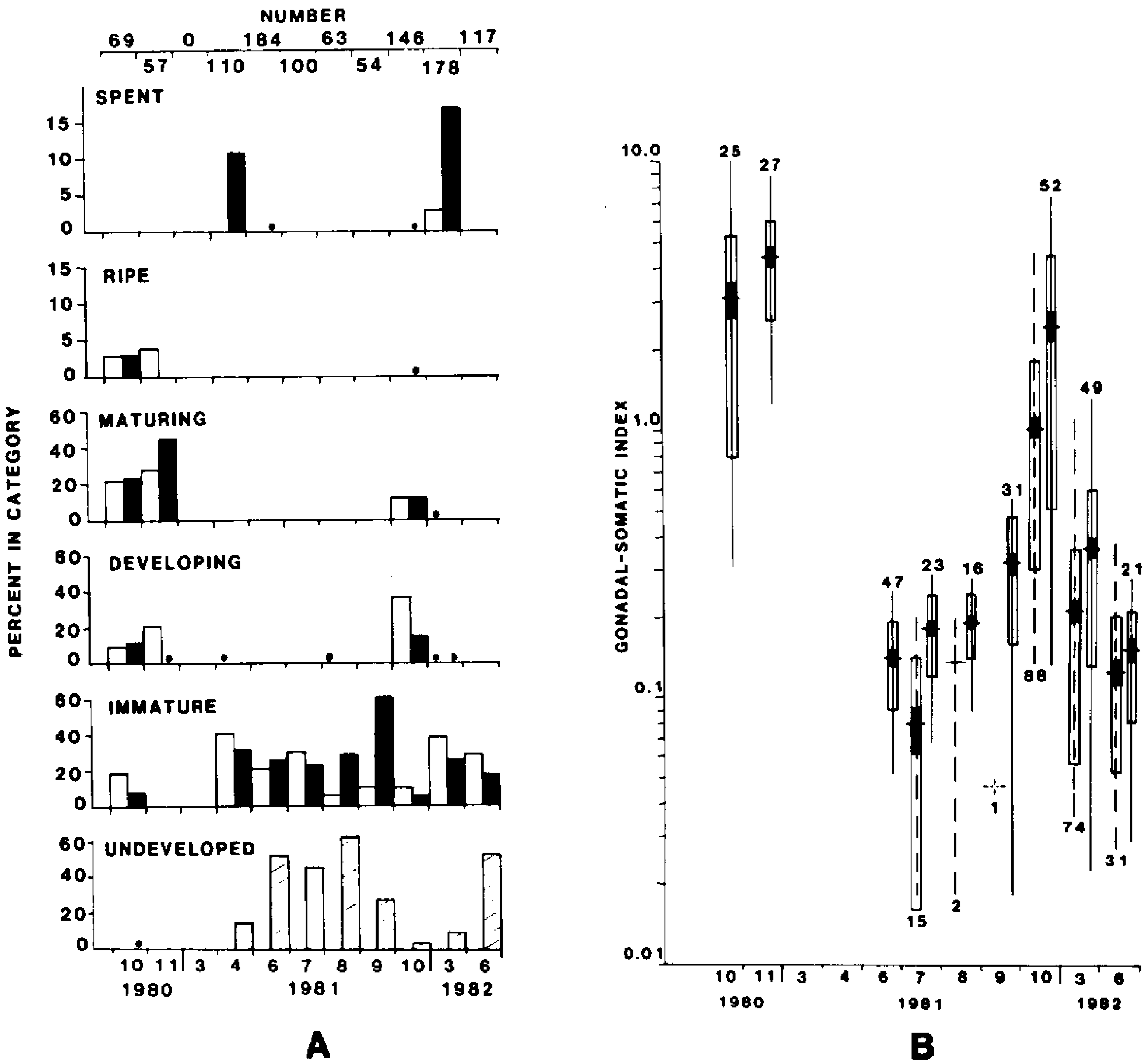

FIG. 3. Spot. (A) Monthly maturation stages. Open bar = male, black bar = female, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

and two maturing females were identified in March 1982 off Louisiana (RV *OREGON II* Cruise 125, B.A. Rohr, NMFS, Pascagoula, Mississippi, personal communication) and we collected a spent female in June 1981. These data suggest a fall through spring spawning season with a fall peak, although we did not collect fish in winter. The monthly variation in the gonadal-somatic indices (Fig. 3) indicated peaks in gonadal development only in the fall. December through February has previously been postulated to be the spot spawning period both off Texas (Pearson 1928) and South Carolina (Dawson 1958). There was no indication that maturing or ripe fish were found more frequently in any one depth stratum.

Fecundity was determined for 64 spot from 127 mm (65.1 g) to 195 mm (208.6 g). Fecundities ranged from 20,900 for a 136 mm (78.3 g) fish to 514,400 for a 178 mm (174.5 g) individual. Fecundity was poorly related to fish length and weight but more strongly related to ovary weight:

$$F = -248{,}965 + 2{,}280\ SL, \text{ where } r^2 = 0.43;$$
$$F = -\ 35{,}589 + 664\ W, \text{ where } r^2 = 0.36; \text{ and}$$
$$F = 9{,}098 + 21{,}244\ OW, \text{ where } r^2 = 0.74.$$

Our data appear to be the second and most extensive report on spot fecundity. Dawson (1958) examined two maturing fish from South Carolina that had fecundities of 77,700 eggs (158 mm *SL*) and 83,900 eggs (187 mm *SL*).

Atlantic Croaker

The relationship between length and weight among 1,396 Atlantic croaker (80–319 mm) was:

$$\log_{10} W = -4.37 + 2.87 \log_{10} SL, \text{ where } r^2 = 0.98.$$

Twenty-three percent (326) of the fish examined were sexually undeveloped. The overall sex ratio was 496 males to 594 females or 1:1.25, which was significantly different from a 1:1 ratio ($\chi^2 = 12.79, P < 0.01$). Males outnumbered females only in the October and November 1980 collections. Landry and Armstrong (1980) found a sex ratio strongly favoring females (1:3.13) in quarterly samples from western Louisiana waters. In our samples, sexual identification was first possible at 84 and 80 mm for males and females, respectively. Smallest maturing fish were 110 mm. White and Chittenden (1977) reported maturation at a similar size (140–170 mm *TL*).

Sexually undeveloped Atlantic croaker were most abundant in the June–August collections (Fig. 4). Maturing fish were noted by September and ripe fish were collected primarily in October and November. Spent females were found in March and April. White and Chittenden (1977) postulated spawning from September to late March but, aside from one spent female identified in June 1982, we found no incidence of spring spawning. Other data from RV *OREGON II* surveys around the Mississippi Delta (Cruise 116, April 1981, and Cruise 125, March 1982, B. A. Rohr, personal communication) indicate no ripe Atlantic croaker among 928 fish examined. Peak gonadal development was found in October (Fig. 4). Maturing and ripe fish were collected from 9–73 m depths with no indication of a preferred spawning depth.

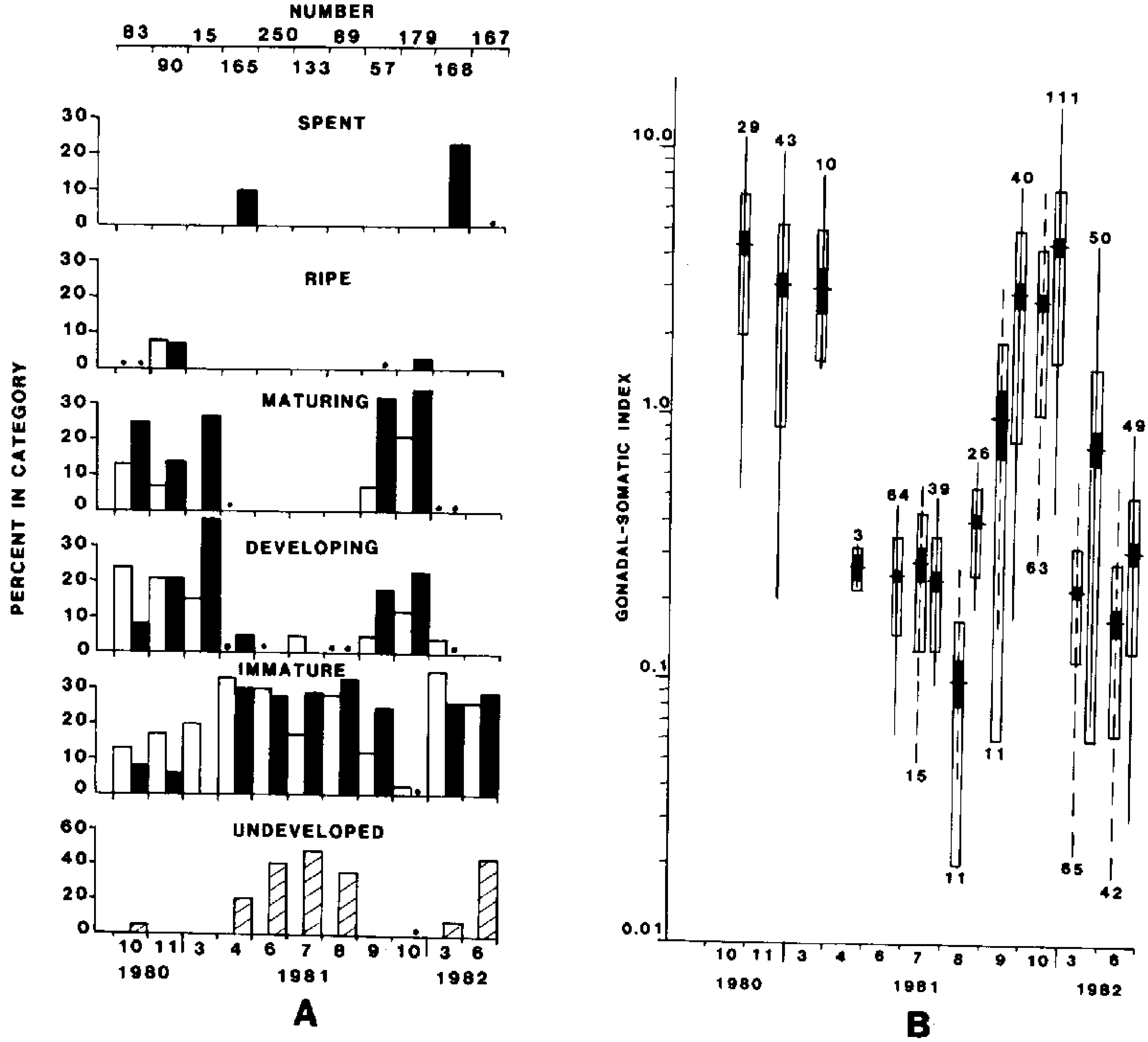

FIG. 4. Atlantic croaker. (A) Monthly maturation stages. Open bar = male, black bar = female, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

Fecundity was determined for 131 fish between 110 and 318 mm (36.7 and 680.4 g). Fecundities ranged between 27,300 for a 132 mm (52.6 g) fish and 1,075,600 for a 318 mm (680.4 g) fish. Fecundity was related to fish length, fish weight, and ovary weight:

$$F = -318{,}340 + 2{,}750\ SL, \text{ where } r^2 = 0.47;$$
$$F = -\ 3{,}248 + 1{,}179\ W, \text{ where } r^2 = 0.63; \text{ and}$$
$$F = 21{,}718 + 17{,}590\ OW, \text{ where } r^2 = 0.81.$$

Morse (1980) examined Atlantic croaker collected between Cape Hatteras, North Carolina and Cape May, New Jersey and reported a fecundity range of

100,800 to 1,742,000 for fish between 196 mm and 390 mm *TL*. No reports on fecundity of Gulf of Mexico fish were located.

Hardhead Catfish

A total of 659 hardhead catfish between 62 and 298 mm was weighed. The majority (540) were collected in 9–17 m waters and only 10 were captured deeper than 37 m. The relationship between length and weight was:

$$\log_{10} W = -4.68 + 2.97 \log_{10} SL, \text{ where } r^2 = 0.99.$$

Of the total examined, 436 or 66% were sexually undeveloped. The overall male to female ratio was 97:126 or 1:1.30, indicating significantly more females than males ($\chi^2 = 4.04$, $P < 0.05$). Only in April and July 1981 were males more numerous than females. The preponderance of females has been recorded elsewhere. Landry and Armstrong (1980) examined 2,236 hardhead catfish from quarterly samples off western Louisiana and found 38% undeveloped fish and a sex ratio of 1:1.98 with females predominating in all sample periods. Ward (1957) reported sex ratios in Mississippi Sound changed from predominantly males in March and April to predominantly females by June, but Pristas and Trent (1978) collected significantly more females during all seasons in St. Andrew Bay, Florida. Etchevers (1978) also found a 1:1.75 male to female ratio for the congeneric *Arius spixii* off Venezuela. The smallest sexually distinct individuals that we found were 141 and 143 mm for males and females, respectively, and the smallest maturing fish were 166 and 180 mm for males and females, respectively. Lee (1937), however, collected gravid females as small as 126 mm and mouth-brooding males at 142 mm in inshore Louisiana waters.

Sexually undeveloped fish dominated all collections except in March 1981 (Campeche Bank, sample of 7 immature fish) and June 1982 (Fig. 5). Although ripe females were collected only in June and July (no ripe males were identified), maturing or spent females were present in 8 of 11 collections. Previous investigators (Lee 1937, Gunter 1947, Ward 1957) have postulated a May–July spawning period in estuarine waters. The monthly variation in the gonadal-somatic indices (Fig. 5) indicated maximum development in June and July. However, results of the visual gonadal classification, coupled with reported collection of 50 mm juveniles in 9–13 m waters off Mobile Bay, Alabama in winter (Gutherz 1981), indicate potential spring through fall spawning with the major peak in early summer.

Fecundity was determined for 27 fish 180 to 298 mm (108.4 to 495.6 g). Fecundities ranged between 6 and 104 eggs (mean = 39). Fecundity was only weakly related to fish length and weight but more strongly related to ovary weight:

$$F = 14.59 + 0.12\ SL, \text{ where } r^2 = 0.14;$$
$$F = 35.67 + 0.02\ W, \text{ where } r^2 = 0.10; \text{ and}$$
$$F = 25.75 + 1.26\ OW, \text{ where } r^2 = 0.68.$$

Ward (1957) found ripe ovaries bearing 40 to 62 eggs 12–14 mm in diameter

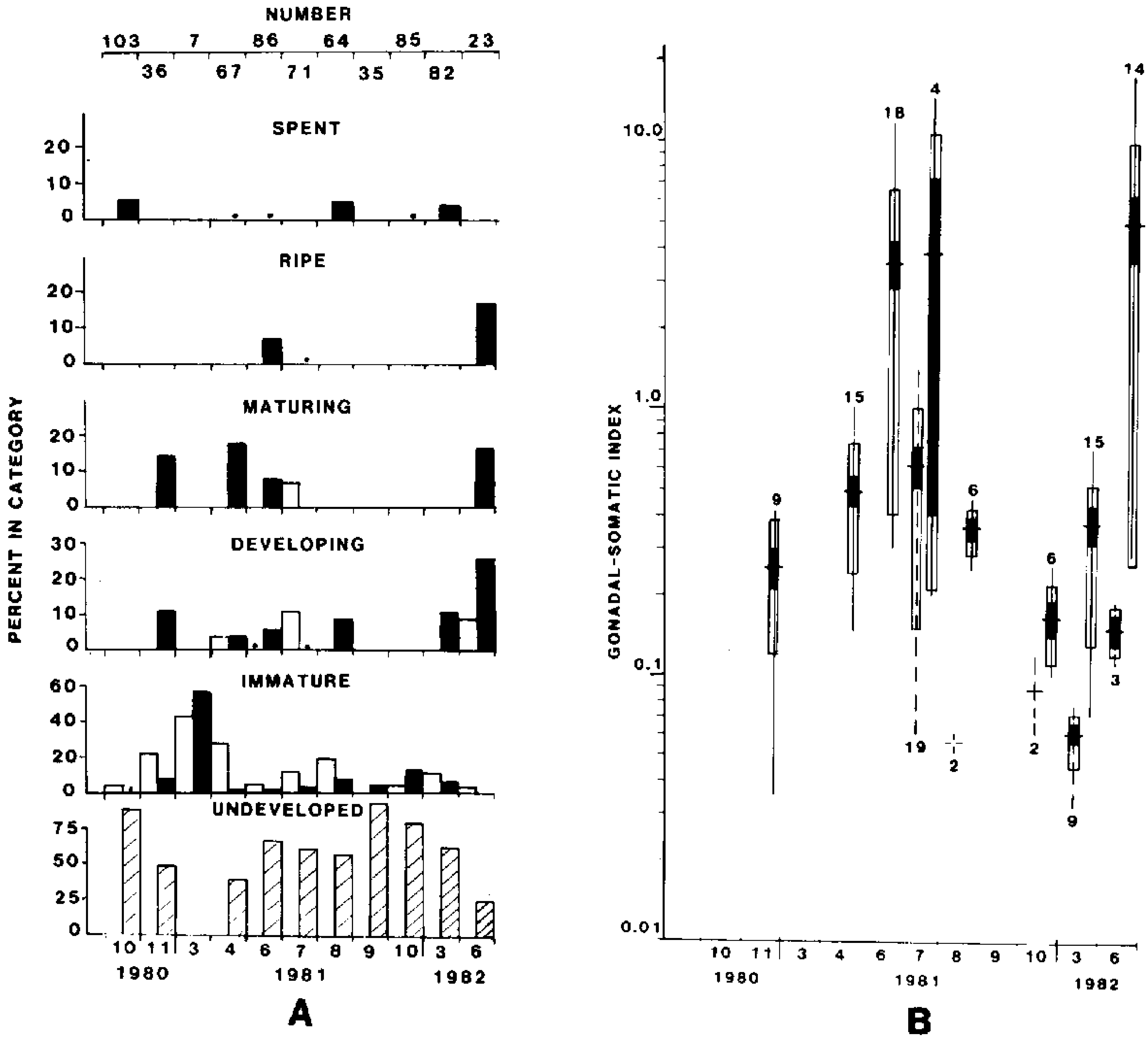

FIG. 5. Hardhead catfish. (A) Monthly maturation stages. Open bar = male, black bar = female, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

with many small, unyolked eggs and stated that ovulated eggs were 14–18 mm wide. We did not collect any males which were mouth-brooding spawned eggs. The largest eggs we measured were 8 mm in diameter. Up to 793 unyolked eggs accompanied the yolked eggs in our samples. The unyolked eggs are apparently released with the viable eggs (Gunter 1947). Fish examined in the present study were in prespawning condition because of small egg diameters, and perhaps because final maturation and spawning occur in estuaries.

Longspine Porgy

The length-weight relationship of 1,426 longspine porgy, 25 to 149 mm, was:

$$\log_{10} W = -4.09 + 2.85 \log_{10} SL, \text{ where } r^2 = 0.97.$$

Sexually undeveloped fish dominated the collections (53.6% or 765 individuals). The overall sex ratio was 293 males to 368 females or 1:1.26, which was significantly different from a 1:1 ratio ($\chi^2 = 8.28, P < 0.05$). Females outnumbered males in all collections except November 1980 and April 1981. Geoghegan and Chittenden (1982) reported a similar sex ratio of 1 male to 1.21 females among 1,506 fish, and Morse (1978) found a 1:1.26 ratio for scup, *S. chrysops*, on the Atlantic coast of the United States. We found that sexual identification was first possible at 60 mm (males) and 52 mm (females). Smallest maturing fish were 77 mm males and 75 mm females.

Sexually undeveloped fish predominated in all but two collections (Fig. 6), representing between 58% and 88% of the fish collected each month. Maturing and ripe fish were found only in April 1981 and March 1982. The monthly gonadal-somatic indices peaked at these times (Fig. 6). Geoghegan and Chittenden (1982) found a similar spawning peak off Texas in February and March in waters deeper than 27 m. During the spawning season, we

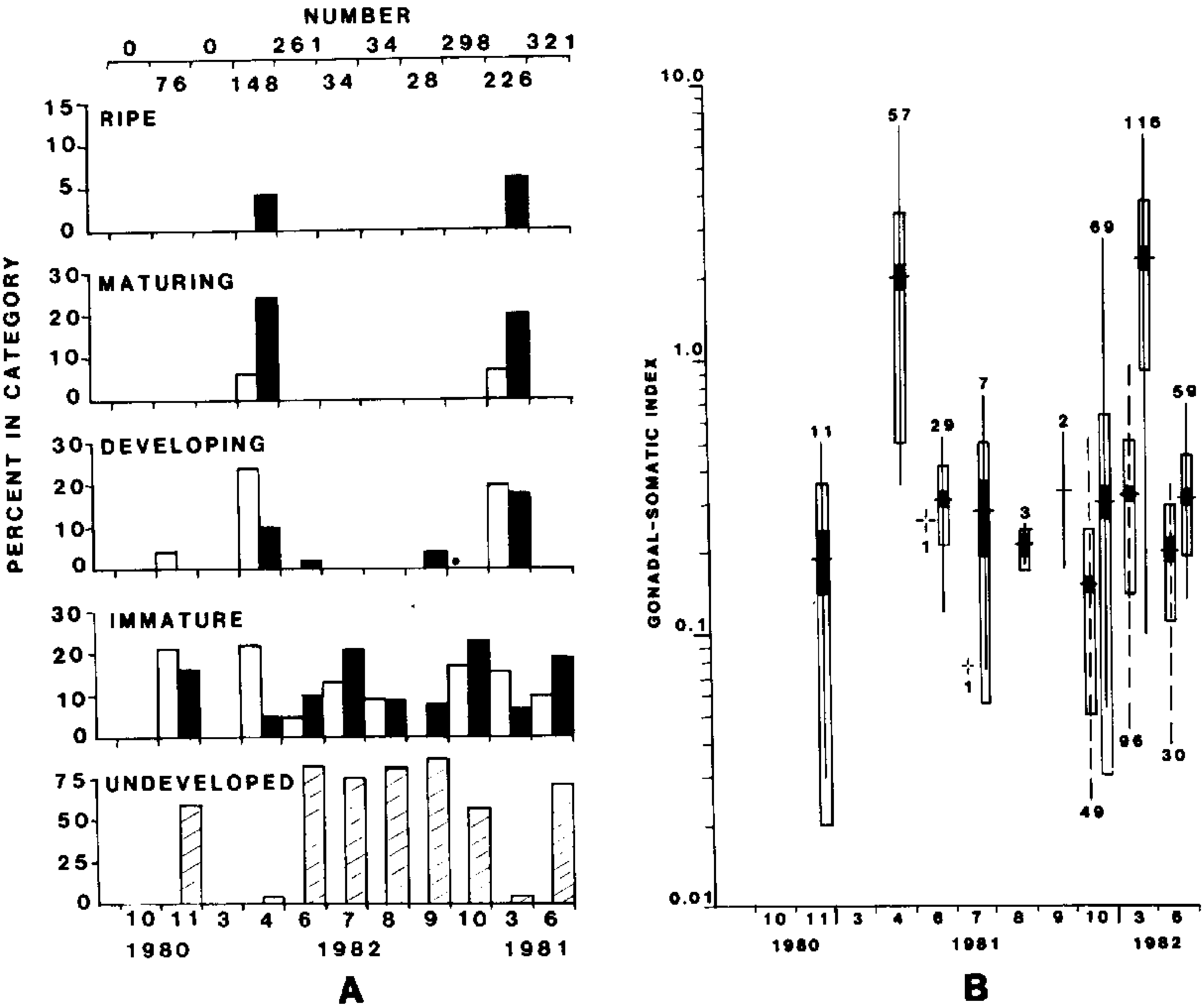

FIG. 6. Longspine porgy. (A) Monthly maturation stages. Open bar = males, black bar = females, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

found maturing and ripe females formed the highest proportions of the population in 56–73 m depths (40/110 fish = 36%) and in 37–55 m depths (35/126 fish = 28%), in contrast to 19% (16/84 fish) in 18–36 m and 20% (8/40 fish) in 74–91 m.

Fecundity was determined for 101 fish 75 to 144 mm (22.9 to 101.4 g). Fecundities ranged between 3,033 in an 82 mm (26.8 g) fish and 43,100 in a 126 mm (71.6 g) individual. Fecundity was poorly related to fish length and weight and moderately related to ovary weight:

$$F = 16{,}262 + 311\ SL, \text{ where } r^2 = 0.28;$$
$$F = 2{,}822 + 271\ W, \text{ where } r^2 = 0.32; \text{ and}$$
$$F = 3{,}307 + 9{,}091\ OW, \text{ where } r^2 = 0.64.$$

Our data are the first concerning the fecundity of longspine porgy. Morse (1978) reviewed biological data on scup, *Stenotomus chrysops*, which are commercially fished between Cape Hatteras and Cape Cod, but found no data on scup fecundity. The red porgy *Pagrus pagrus*, a larger and longer lived sparid, matures at Age II (300 mm TL) and at 600 mm TL could produce 943,000 eggs (Manooch 1976).

Atlantic Cutlassfish

Eight hundred fifty-three Atlantic cutlassfish were weighed and measured, yielding the length-weight relationship:

$$\log_{10} W = -7.28 + 3.37 \log_{10} TL, \text{ where } r^2 = 0.97.$$

Specimens ranged from 133 to 923 mm. Sexually undeveloped fish composed 32% of the collection. The overall sex ratio was 360 males to 220 females or 1.64:1, which was significantly different from a 1:1 ratio ($\chi^2 = 33.31, P < 0.01$). Males outnumbered females in all collections except August 1981. Mericas (1981), however, reported a contrasting 1:1.51 sex ratio in a sample of 250 fish from Mississippi Delta waters. These opposing sex ratios may be due to contrasting sample characteristics: Mericas' specimens ranged between 380 and 1,000 mm *TL* and came only from industrial boats fishing the primary grounds, whereas our specimens came from wider size and geographical ranges. In Cuban waters, Ros Pichs and Castillo (1978) found that sex ratios of 393 Atlantic cutlassfish varied monthly (September–March) but favored males among 500–750 mm fish, females among 800–1050 mm fish, and females overall (280–1050 mm). Chi-square analysis of our data indicated significantly more males than females among 250–499 mm fish ($\chi^2 = 35.01, P < 0.01$) but more females than males in 500–923 mm fish ($\chi^2 = 5.17, P < 0.025$). In our samples sexual identification was first possible at 250 mm (males) or 264 mm (females). Smallest maturing Atlantic cutlassfish were a 387-mm male and a 350-mm female. Comparable identifications among Cuban specimens (Ros Pichs and Castillo 1978) were made with a 500-mm male and a 440-mm female (sexual distinction) and with a 750-mm male and a 710-mm female (first maturation). Different sampling seasons may have caused the wide discrepancy between our results and those from Cuba.

Both sexually undeveloped fish and maturing individuals were found throughout the year (Fig. 7). Ripe females were collected in April, June,

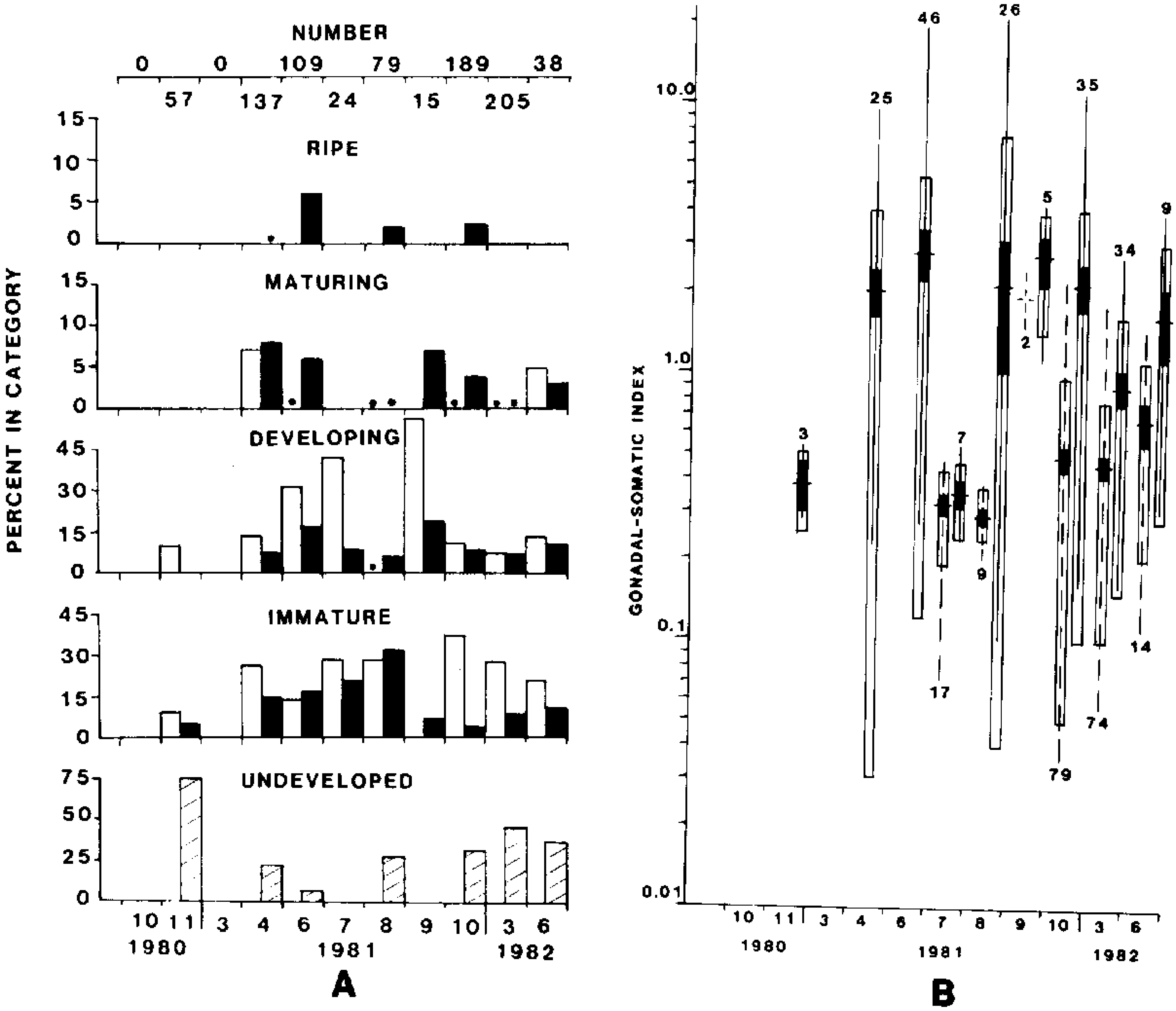

FIG. 7. Atlantic cutlassfish. (A) Monthly maturation stages. Open bar= male, black bar = female, shaded bar = undeveloped, dot = ≤ 2% occurrence. (B) Monthly gonadal-somatic indices. Vertical line = range, horizontal line = mean, open rectangle = ± 1 standard deviation, black rectangle = ± 1 standard error. Males indicated by dashed vertical line with number examined below, females by solid vertical line with number examined above.

August, and October 1981, which indicated an extended spawning season. Monthly gonadal-somatic indices (Fig. 7) also reflected a long season with a possible summer peak. Maturing or ripe fish were collected throughout the 9–91 m depth range sampled. In contrast, Dawson (1967) postulated winter spawning at depths exceeding 36 m (his maximum sampling depth) off Grande Isle, Louisiana. Our widespread sampling, including deeper waters, is the probable source of contrasting results, since similar sampling methods and gear were employed in both our study and Dawson's.

Fecundities were determined for 42 fish 350 mm (30.7 g) to 920 mm (523.2 g). Fecundities varied from 5,000 for a 420-mm (35.9 g) fish to 42,100 for the 920-mm fish but were poorly related to fish length, fish weight, and ovary weight:

$$F = -\ 9{,}705.98 + 47.80\ TL, \text{ where } r^2 = 0.38;$$
$$F = 9{,}026.93 + 64.76\ W, \text{ where } r^2 = 0.41; \text{ and}$$
$$F = 13{,}084.94 + 608.23\ OW, \text{ where } r^2 = 0.13.$$

Our data are the second report on the fecundity of Atlantic cutlassfish. Ros Pichs and Castillo (1978) determined fecundities ranging from 18,000 eggs for a 710-mm (235 g) fish to 193,000 eggs for a 970-mm (735 g) fish. Sources of variation for the lack of correlation between fecundity and ovary weight are discussed later.

FOOD HABITS

Sand Seatrout

We examined 767 sand seatrout stomachs, 471 (61.4%) of which contained food (Table 2). Fishes were the primary food for each age/area/time class

TABLE 2

Stomach contents of sand seatrout, *Cynoscion arenarius*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (33-149 mm SL)				Age I (150-310 mm SL)			
	East		West		East		West	
Stomach contents	Day	Night	Day	Night	Day	Night	Day	Night
Nematodes	-	-	-	-	-	+	+	+
Polychaetes	-	0.7	0.3	-	-	-	-	-
Octopi	-	-	-	-	-	-	-	0.4
Squid	-	-	0.4	-	0.1	10.6	0.9	2.3
Stomatopods	-	-	1.9	-	0.4	3.2	1.8	0.9
Mysids	2.2	-	0.1	-	0.1	+	-	0.1
Isopods	-	-	-	-	-	-	+	-
Amphipods	-	-	+	-	-	-	-	-
Shrimp	36.6	19.6	24.5	2.3	48.4	19.4	28.4	35.1
Crabs	-	0.6	0.6	-	+	0.6	0.5	+
Crab larvae	-	0.9	4.9	-	-	+	+	+
Invertebrate eggs	-	-	-	-	-	-	+	-
Fishes	61.2	78.3	64.3	97.7	51.0	66.2	68.4	61.2
Total identified dry weight (g)	0.663	1.664	3.578	1.998	6.222	34.594	14.057	46.186
Animal fragments (g)	-	0.184	0.110	-	0.351	0.796	0.875	0.524
Detritus (g)	0.040	0.031	0.146	0.007	0.248	0.455	0.831	0.477
Stomachs with food	8	32	105	6	32	83	87	118
Stomachs examined	11	61	129	10	87	140	136	193

(51–98% by dry weight), and shrimps of all types were the second most abundant food (2–48%). On occasion, squid, stomatopods, mysids, or crab larvae comprised up to 11% of the diets. Twelve fish taxa were identified in sand seatrout stomachs; *Anchoa* comprised 47% and *Bregmaceros* 13%. Other fish taxa occurred only once or twice. Twelve shrimp taxa were noted, most frequently among them *Trachypenaeus* (47%) and *Acetes* (27%). Among other penaeid shrimps, we found six specimens of *Xiphopenaeus*, three *Penaeus*, and two each of *Parapenaeus, Sicyonia*, and *Solenocera*.

Previous investigations in the Gulf of Mexico have yielded results similar to ours. Rogers (1977) reported a diet of 61% (by volume) fish, 20% squid, and 15% shrimp in Age 0 sand seatrout from Texas and Louisiana shelf waters. Off western Louisiana, Landry and Armstrong (1980) found seasonal variations of 51–76% (dry weight) fish and 9–27% shrimp in collections combining Age 0 and I sand seatrout. Sheridan and Trimm (1983) also noted a fish- and shrimp-dominated diet in Texas waters that was little affected by age and habitat.

Silver Seatrout

A total of 632 silver seatrout stomachs were examined, of which 429 (67.8%) contained food (Table 3). Fishes were the primary food of 7 of 8

TABLE 3

Stomach contents of silver seatrout, *Cynoscion nothus*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (32-149 mm SL)				Age I (150-280 mm SL)			
	East		West		East		West	
Stomach contents	Day	Night	Day	Night	Day	Night	Day	Night
Nematodes	-	-	0.2	-	+	-	0.3	+
Polychaetes	-	-	+	0.4	-	-	-	-
Gastropods	-	-	0.2	-	-	-	-	-
Bivalves	-	-	0.8	-	-	-	-	-
Squid	-	-	-	8.9	-	1.2	+	2.8
Calanoid copepods	0.2	5.3	-	+	-	-	-	+
Stomatopods	0.1	-	0.8	0.4	-	2.5	0.4	0.4
Mysids	19.2	14.1	0.5	1.5	-	-	+	1.7
Cumaceans	0.2	0.1	0.1	0.1	-	-	+	-
Amphipods	0.6	0.7	0.1	0.8	-	-	0.2	0.7
Shrimp	46.8	11.2	26.8	32.2	0.4	24.1	14.8	42.1
Shrimp larvae	-	-	-	+	-	-	-	-
Crabs	0.2	-	1.8	0.8	1.6	1.5	1.2	0.6
Crab larvae	1.6	-	0.3	-	0.1	-	1.1	0.9
Insects	0.2	-	-	-	-	-	-	-
Fishes	30.2	65.6	65.7	55.0	97.9	70.8	81.9	50.8
Total identified dry weight (g)	0.442	1.494	3.404	2.288	2.937	8.893	4.681	4.771
Animal fragments (g)	0.012	0.070	0.549	0.117	0.033	0.098	0.466	0.247
Detritus (g)	0.018	0.048	0.789	0.162	0.042	0.176	0.371	0.438
Stomachs with food	21	55	134	71	7	29	57	55
Stomachs examined	30	68	188	90	27	38	105	86

age/area/time classes (51–98% by dry weight), the exception being Age 0/East/Day where shrimps were the main prey (47%). Shrimps were generally the second most abundant food, comprising 0.4–47% of the diet. Mysids were important food (14–19%) to Age 0 fish on the East Delta but not on the West Delta. Squid, calanoid copepods, stomatopods, and crab larvae occasionally formed between 1% and 9% of the diet. Age 0 and East Delta fish generally ate more shrimp and less fish than did Age I and West Delta fish. Nine fish taxa and 8 shrimp taxa were found in silver seatrout stomachs. *Bregmaceros* (30%), *Anchoa* (30%), and *Centropristis* (10%) were the most frequently identified fish genera; 6 other taxa occurred only once. *Acetes* (35%), *Trachypenaeus* (31%), and alpheids (17%) were the most common shrimps. One specimen of each of the penaeids *Sicyonia* and *Solenocera* were identified.

Fish and shrimp have been reported elsewhere as the primary foods of silver seatrout in the Gulf of Mexico, but previous studies have generally involved smaller individuals and have not considered age or time of capture as possible factors influencing diets. Rogers (1977) collected 26–175 mm specimens from western Florida into Texas waters and found an overall diet of 56% fish and 19% shrimp by volume. He documented a shift from a 40% shrimp–18% mysid diet in 26–50 mm fish to a 77% fish–8% shrimp diet in 76–175 mm fish but did not specify collecting times. Landry and Armstrong (1980) reported a seasonal shift in diet off western Louisiana from fish in spring and summer to shrimp in fall. Their nocturnal collections consisted mainly of Age 0 fish from a single location. In collections limited to nocturnal samples over a short summer period, Sheridan and Trimm (1983) found that age and depth of capture influenced diets off Texas.

Spot

We examined 760 stomachs and found only a small proportion (32.7%) containing food (Table 4). Spot have relatively small stomachs that are easily ruptured when expanded by food. Swim bladder expansion after trawl capture in many cases burst the stomachs and intestines, rendering the specimen useless for food analysis. Although 140 Age II and III specimens were collected, they usually came from deeper water and empty or ruptured stomachs were prevalent. Data from these fish were minimal and were thus included with the Age I data. Spot consumed a wide variety of foods, but polychaetes and detrital matter formed the bulk of the diet. Calanoid copepods and amphipods were prominent daytime foods on both sides of the Mississippi Delta, as were cumaceans on the east side, while polychaete consumption was generally higher at night in both areas. *Acetes* and *Lucifer* were the only shrimps found, and we were unable to identify any of the rarely occurring crabs or fishes.

Two other studies of the offshore foods of spot have been conducted. Chen (1976) collected spot primarily from the East Delta region in fall and winter. Her largely Age I–III individuals had consumed detritus/sediment (68% by volume), polychaetes (23%), shrimp (6%), and amphipods (2%). Our data from the same area indicated similar consumption of polychaetes, shrimp, and amphipods but lower intake of detritus (17–22%) and higher intake of

TABLE 4

Stomach contents of spot, *Leiostomus xanthurus*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (63-124 mm SL)			Age I (125-197 mm SL)			
	East		West[a]	East		West	
Stomach contents	Day	Night	Day	Day	Night	Day	Night
Sand	-	4.5	1.6	4.5	22.3	4.4	-
Plant matter	-	-	0.2	-	1.5	0.1	0.1
Nematodes	-	1.8	1.4	2.6	3.2	0.1	-
Polychaetes	11.4	94.1	71.6	23.9	34.3	63.0	92.6
Gastropods	-	-	0.1	-	-	0.2	-
Bivalves	-	0.6	0.4	0.7	2.2	0.6	-
Ostracods	-	-	+	-	-	-	-
Calanoid copepods	12.3	-	11.4	17.2	0.9	11.8	0.4
Harpacticoid copepods	-	0.3	2.6	0.8	0.6	0.2	0.2
Stomatopods	-	-	-	-	-	0.2	-
Mysids	-	-	2.3	1.2	0.6	2.1	-
Cumaceans	49.5	0.3	0.2	28.1	2.7	0.3	-
Isopods	-	-	0.1	0.2	+	+	-
Amphipods	8.1	0.2	3.6	11.5	2.7	5.3	0.1
Shrimp	0.6	0.3	2.8	6.8	+	7.1	2.0
Shrimp larvae	-	-	-	-	0.5	0.1	-
Crabs	-	-	0.1	0.8	0.1	2.8	1.2
Crab larvae	-	-	0.4	-	-	0.2	0.2
Insects	-	-	-	-	0.8	-	-
Ophiuroids	16.5	-	-	0.2	0.1	-	-
Sea urchins	-	-	-	-	0.2	-	-
Sand dollars	-	-	-	-	+	-	-
Lancelets	-	-	-	-	26.9	+	-
Fishes	-	-	1.2	-	0.2	1.5	3.2
Fish eggs	1.6	-	-	1.5	0.1	-	-
Total identified dry weight (g)	0.043	0.348	0.338	0.193	1.429	1.134	0.391
Animal fragments (g)	0.003	0.104	0.226	0.020	0.351	0.165	0.069
Detritus (g)	0.046	0.070	0.377	0.044	0.495	0.435	0.024
Stomachs with food	3	10	75	30	55	54	22
Stomachs examined	9	27	143	82	174	173	152

[a] No Age 0 spot were collected from the West at night

calanoid copepods, cumaceans and lancelets. Off the Texas coast (Sheridan and Trimm 1983), Age 0 spot fed mainly upon detritus (62%) and various crustaceans while Age I spot consumed less detritus (37%) and began preying upon fish (17%).

Atlantic Croaker

The stomachs of 430 of 976 fish (44.1%) contained food (Table 5). Only 2 of 11 Age III fish stomachs contained food, and data from these fish were combined with that from Age II. Our data indicate that while Age 0 Atlantic croaker tended to feed upon polychaetes (67–79% of their diets), Ages I and II fish fed upon larger, mobile organisms such as stomatopods (59% by Age II/East/Day and Night), shrimps (28–100%), crabs (59% by Age I/East/Night, 68% by Age II/West/Day), or fishes (5–40%). Atlantic croaker preyed

TABLE 5

Stomach contents of Atlantic croaker, *Micropogonias undulatus*, collected from the Mississippi Delta Between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (80-124 mm SL)			Age I (125-199 mm SL)				Age II (200-318 mm SL)			
	East[a]	West		East		West		East		West	
Stomach contents	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Sand	-	-	+	-	7.1	-	-	-	0.7	-	-
Plant matter	-	-	-	+	-	-	-	-	-	-	-
Nematodes	-	0.4	0.8	1.0	0.4	0.2	0.1	0.2	-	-	-
Polychaetes	67.1	79.0	76.3	24.2	14.3	69.3	18.1	5.8	2.7	-	-
Gastropods	-	-	-	-	+	-	-	-	-	-	-
Bivalves	-	0.1	-	+	-	-	-	-	-	-	-
Squid	-	0.5	-	-	0.8	-	-	-	-	-	-
Calanoid copepods	-	-	+	+	-	0.1	0.1	-	-	-	-
Barnacles	-	-	+	-	-	-	-	-	-	-	-
Stomatopods	-	-	-	15.6	-	2.1	3.2	58.6	58.9	10.4	-
Mysids	-	0.1	0.3	0.9	+	0.2	0.1	-	-	-	-
Isopods	-	-	-	-	-	-	-	+	-	-	-
Amphipods	-	0.1	0.1	0.3	0.1	+	+	-	0.1	-	-
Shrimps	13.8	10.9	7.4	28.2	7.2	4.9	32.2	0.3	32.1	-	100.0
Crabs	7.8	1.3	11.0	10.3	59.2	9.3	6.2	-	0.2	68.1	-
Crab larvae	-	0.1	-	+	-	0.1	-	-	-	-	-
Invertebrate eggs	-	0.1	-	0.5	0.3	0.1	-	0.3	-	-	-
Tunicates	-	+	-	-	-	-	-	-	-	-	-
Lancelets	-	-	-	-	+	-	-	-	-	-	-
Fishes	11.0	5.3	4.0	18.9	10.1	13.6	40.0	34.7	5.4	21.4	-
Fish eggs	-	+	-	-	0.4	-	-	-	-	-	-
Total identified dry weight (g)	0.090	1.737	1.198	1.229	2.759	2.341	3.040	1.196	3.185	1.053	1.528
Animal fragments (g)	-	0.632	0.120	0.137	0.521	0.344	0.687	0.545	0.082	-	0.013
Detritus (g)	0.027	0.815	0.073	0.305	0.520	0.533	0.545	0.105	0.096	-	0.017
Stomachs with food	8	130	48	29	57	75	62	9	8	2	2
Stomachs examined	16	160	59	102	201	174	209	22	24	6	3

[a] No Age 0 fish were collected from the East during daylight

upon seven taxa of shrimps (primarily *Acetes* (33%) and *Trachypenaeus* (19%) of those identified), five crab taxa (one occurrence each of *Albunea, Callinectes*, pagurids, *Raninoides*, and xanthids), and four types of fishes (50% *Bregmaceros*).

The feeding habits of Atlantic croaker have been the subject of numerous studies in the Gulf of Mexico, most of which have shown that polychaetes are the primary food of smaller individuals and large crustaceans and fishes are added to the diet with growth (Chen 1976, Rogers 1977, Overstreet and Heard 1978, Landry and Armstrong 1980, Sheridan and Trimm 1983). These same reports show the variability in diet components; for example, Chen (1976) observed similar diets among size classes, but Sheridan and Trimm (1983) found no correlations in diets among Age 0 and I in two habitat types.

Hardhead Catfish

Almost all of the 547 stomachs contained food (92.7%). Fish ranged up to 298 mm *SL* and probably included some Age II individuals, but little is known of the growth rates and longevity of the species. Hardhead catfish ingested a broad spectrum of foods (Table 6). Feeding habits were affected by both age and area but not by time of day. Age 0 fish from the East Delta preyed mainly upon polychaetes (64% and 68% of the diets), but consumed fewer polychaetes and more shrimp and fish bones and scales on the West Delta. Small sample sizes from the East Delta may have been responsible for these differences. Age I hardhead catfish also consumed some polychaetes (8–33% of the diets) but began preying upon larger epifauna such as stomatopods, shrimps, and fishes on the West Delta and crabs on the East Delta. Hardhead catfish preyed upon 10 shrimp taxa, dominated by burrowing alpheids and *Ogyrides* (29%), epifaunal *Trachypenaeus* (23%), and planktonic sergestids such as *Acetes* and *Lucifer* (17%). Among 14 taxa of crabs, we found *Pinnixa* most often (29%), followed by xanthids (22%),

TABLE 6

Stomach contents of hardhead catfish, *Arius felis*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (62-149 mm SL)				Age I (150-298 mm SL)			
	East		West		East		West	
Stomach contents	Day	Night	Day	Night	Day	Night	Day	Night
Sand	0.3	0.2	0.2	-	1.3	3.9	0.2	-
Plant matter	-	-	+	-	-	0.8	+	-
Anemones	-	-	0.5	-	-	-	-	1.0
Rhynchocoels	-	-	0.9	-	-	-	-	-
Nematodes	-	0.4	+	-	+	+	+	+
Polychaetes	68.0	64.4	40.1	18.7	32.6	9.8	23.5	7.6
Gastropods	-	-	0.2	0.2	3.5	0.1	0.2	0.1
Bivalves	-	-	-	-	+	0.4	0.2	-
Squid	-	-	+	-	-	0.2	+	-
Calanoid copepods	6.9	0.2	0.5	+	+	+	+	-
Harpacticoid copepods	-	0.5	+	-	+	-	-	-
Barnacles	-	-	-	-	0.1	-	-	-
Stomatopods	0.1	-	1.8	-	0.4	13.9	16.2	16.3
Mysids	0.1	4.8	+	2.9	+	0.2	+	+
Cumaceans	1.6	0.8	+	-	-	+	-	-
Isopods	-	-	-	-	-	-	-	0.2
Amphipods	1.2	4.0	0.3	-	0.1	0.5	-	-
Shrimps	0.3	3.0	7.1	17.9	1.5	3.2	19.2	47.6
Shrimp larvae	1.4	0.9	0.1	-	+	+	+	+
Crabs	9.5	3.7	10.2	3.1	36.4	37.3	18.6	10.8
Crab larvae	0.6	0.8	1.0	0.4	0.1	0.1	+	+
Invertebrate eggs	1.1	-	1.9	-	0.3	+	0.3	+
Insects	-	-	0.6	-	-	0.1	+	-
Holothurians	-	-	0.3	-	-	-	1.4	-
Chaetognaths	-	-	-	-	+	-	-	-
Lancelets	0.1	2.7	-	-	-	0.1	-	-
Fishes	3.0	-	0.3	2.5	3.1	1.1	6.2	10.9
Fish bones + scales	4.8	0.4	33.8	39.6	13.6	28.2	13.9	5.3
Fish eggs	1.1	13.4	+	14.7	0.1	0.1	+	-
Total identified dry weight (g)	0.549	0.673	4.736	1.806	10.663	19.224	36.822	28.165
Animal fragments (g)	0.147	0.130	1.957	1.081	1.557	5.341	6.760	2.783
Detritus (g)	0.093	0.057	1.193	0.882	0.905	3.632	2.654	0.494
Stomachs with food	5	9	159	32	35	79	133	55
Stomachs examined	5	9	165	32	36	88	148	64

pagurids (12%), and *Ovalipes* (10%). Fifty percent of the 7 taxa of prey fishes were *Anchoa*.

Only two other quantitative studies have examined the offshore foods of hardhead catfish. Landry and Armstrong (1980) reported crabs and polychaetes as the primary spring through fall foods of Age I fish in the Weeks Island, Louisiana area. Sheridan and Trimm (1983) found that during summer nights off Texas, hardhead catfish prey primarily upon stomatopods, crabs, shrimps, and holothurians.

Longspine Porgy

Slightly more than half of the longspine porgy stomachs examined contained food (595/1,096, 54.3%). A wide variety of food was consumed but two main feeding groups emerged: East Delta versus West Delta (Table 7). Longspine porgy from the West Delta generally consumed more shrimps, crabs, and fishes and less polychaetes than did fish from the East Delta. Some age-related changes in diet were apparent, as older individuals tended to consume more fish and fewer polychaetes. Because longspine porgy tend to macerate food, prey taxa were rarely identified. Alpheids appeared to be the most frequent shrimp, while *Raninoides* and xanthids were the only crabs identified.

Henwood, Johnson and Heard (1978) examined longspine porgy diets from the East Delta region and noted that polychaetes, amphipods, crabs, shrimps, and harpacticoid copepods were the most frequently occurring foods. Unfortunately, their data were only summaries even though day and night collections and Ages 0–II were sampled. Rogers (1977) found polychaetes to be the primary food in West Delta and Texas waters and that Age I individuals consumed more fishes and shrimps than did Age 0 fish. Sheridan and Trimm (1983) also found polychaetes to be the primary food of fish off Texas.

Atlantic Cutlassfish

We examined 743 Atlantic cutlassfish stomachs and 560 (75.4%) contained food. This species was almost exclusively piscivorous (Table 8), but occasionally consumed large amounts of squid and shrimps. Although 12 taxa of fishes and 4 taxa of shrimps were identified, 50% of the fishes were *Anchoa* and 76% of the shrimps were *Acetes*. Mericas (1981) and Sheridan and Trimm (1983) reported that Atlantic cutlassfish were piscivores.

SUMMARY AND CONCLUSIONS

REPRODUCTION

Some of our result agree and others contrast with those of previous studies of reproduction in these Gulf fishes. Sex ratios for Atlantic croaker, hardhead

TABLE 7

Stomach contents of longspine porgy, *Stenotomus caprinus*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; W = 89°30′–94°00′W), and time of collection. + = < 0.1%.

	Age 0 (25-74 mm SL)				Age I (75-124 mm SL)				Age II (125-149 mm SL)		
	East		West		East		West		East		West[a]
Stomach contents	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
Sand	9.2	18.4	6.8	-	4.8	0.5	3.5	2.9	11.6	-	-
Plant matter	-	-	-	-	-	0.2	-	-	-	-	-
Rhynchocoels	5.5	-	-	-	-	-	-	-	-	-	-
Nematodes	1.1	-	-	-	0.2	0.3	0.8	1.8	-	-	-
Polychaetes	68.4	56.9	41.8	42.7	68.8	82.4	61.2	45.9	19.7	22.5	22.9
Gastropods	-	-	6.8	-	0.1	-	+	-	-	72.2	-
Bivalves	-	-	-	-	5.5	0.1	-	1.3	1.9	-	-
Squid	-	-	-	-	1.7	-	-	11.7	-	-	-
Ostracods	-	-	-	-	-	-	-	0.3	-	-	-
Calanoid copepods	1.1	0.3	4.7	3.0	0.3	0.1	0.7	0.4	1.5	-	-
Harpacticoid copepods	-	-	1.6	-	+	0.1	-	-	-	-	-
Barnacles	-	-	-	-	-	-	-	-	-	-	19.3
Stomatopods	9.4	-	-	-	0.4	+	1.0	2.0	10.6	-	-
Mysids	-	3.6	-	36.0	0.1	4.7	0.1	0.2	-	-	-
Cumaceans	-	-	-	-	0.1	+	-	-	1.0	-	-
Isopods	-	-	-	-	-	-	+	-	-	-	-
Amphipods	-	2.1	5.7	-	0.7	1.7	0.5	1.9	-	-	-
Shrimps	-	7.8	26.1	12.8	8.2	4.0	12.5	5.1	2.5	-	17.6
Crabs	-	5.4	6.8	-	2.1	3.4	9.0	11.3	21.2	-	3.2
Crab larvae	-	3.1	-	-	-	0.5	0.3	+	-	-	-
Invertebrate eggs	-	-	-	-	-	0.1	3.4	-	0.6	-	0.1
Brachiopods	4.7	0.4	-	-	0.7	0.1	-	-	-	5.3	-
Fishes	1.1	1.4	-	5.2	6.1	1.3	6.9	15.2	29.6	-	37.1
Fish eggs	-	-	-	-	0.2	-	-	-	-	-	-
Total identified dry weight (g)	0.036	0.078	0.019	0.152	1.264	1.517	1.112	0.982	0.150	0.016	0.697
Animal fragments (g)	0.035	0.040	0.015	0.102	0.516	1.034	0.251	0.464	0.121	0.038	0.008
Detritus (g)	0.011	0.130	0.013	0.075	0.580	0.256	0.357	0.629	-	0.011	0.056
Stomachs with food	7	43	12	40	107	147	89	117	14	6	13
Stomachs examined	10	56	19	79	162	250	166	281	28	15	30

[a] No Age II fish were collected from the West at night

TABLE 8

Stomach contents of Atlantic cutlassfish, *Trichiurus lepturus*, collected from the Mississippi Delta between October 1980 and July 1982, expressed as percentages of total food dry weight by age, location (East = 87°20′–89°30′W; West = 89°30°–94°00′W), and time of collection, + = < 0.1%. Age II data summed due to small numbers collected.

	Age 0 (133-399 mm TL)				Age I (400-699 mm TL)				Age II (700-923 mm TL)
	East		West		East		West		East + West
Stomach contents	Day	Night	Day	Night	Day	Night	Day	Night	Day + Night
Squid	-	-	+	-	-	0.1	24.2	32.7	-
Calanoid copepods	0.2	5.5	+	-	-	-	-	-	-
Stomatopods	0.1	0.2	+	0.5	-	-	-	-	-
Mysids	0.4	0.3	-	-	-	-	-	-	-
Amphipods	0.2	-	+	-	-	-	+	-	-
Shrimp	4.7	8.8	16.5	8.3	2.7	1.6	16.1	10.3	5.1
Crabs	-	-	-	-	-	-	+	-	-
Crab larvae	0.9	0.1	0.2	0.2	+	-	0.5	-	-
Fishes	93.5	85.0	83.2	91.0	97.3	98.3	59.0	56.9	94.9
Total identified dry weight (g)	4.652	2.271	16.969	4.213	7.064	10.556	6.691	2.778	23.802
Animal fragments (g)	0.509	0.019	0.163	0.052	0.203	0.007	0.550	0.004	0.010
Detritus (g)	0.076	0.046	0.029	0.033	0.186	0.014	0.108	0.006	0.069
Stomachs with food	134	29	235	33	44	12	48	17	8
Stomachs examined	187	35	284	48	58	13	70	37	11

catfish, and longspine porgy have been found to favor females, while sex ratios for spot, Atlantic cutlassfish, and sand and silver seatrouts vary from study to study. We feel that our data are representative of northern Gulf populations because of our extensive collections. For six of the seven species, our data on reproductive cycles compare favorably to data from previous studies. We disagree only with Dawson (1967), who proposed winter spawning for Atlantic cutlassfish. Our data indicate relatively high reproductive activity from April through September. Our gonadal-somatic indices represent the first such quantitative information for Gulf fishes. Ovarian development appears to be continuous during the spawning seasons of all seven species as indicated by a mixture of egg sizes in maturing and ripe ovaries. The fishes probably release eggs several times during the spawning period. Goldberg (1976, 1981) has described similar spawning in three California sciaenids, *Genyonemus lineatus, Seriphus politus*, and *Cheilotrema saturnus*, which are morphologically similar to Atlantic croaker, seatrout, and spot, respectively (Miller and Lea 1972).

Longspine porgy, Atlantic croaker, and spot apparently have high reproductive activities in spring or fall. However, lack of sampling from December through February could have led us to describe incompletely their reproductive cycles. Geoghegan and Chittenden (1982) examined ovarian development of longspine porgy from October 1978 through March 1980 in Texas waters. They recorded peak frequencies of gravid females in March 1979 and again in March 1980. Winter probably represents a ripening period around the Mississippi Delta as well, since our data indicate March and April as spawning months. We observed a peak gonadal-somatic index for female Atlantic croaker in October 1980, followed by a decline in November 1980, a subsequent rise in August–September 1981, and another peak in October, 1981. This sequence appears to define the major reproductive peak for the species around the Mississippi Delta, while winter represents the final stages of reproduction. We apparently did not characterize the peak gonadal development of spot, based upon Pearson's (1928) conclusion of maximum spawning activity in January and February off Texas.

Our fecundity data are, for the most part, new information for Gulf of Mexico fishes. Few comparisons could be made for these species or their congeners along the Atlantic coast. Within the Gulf, silver seatrout appear less fecund than sand seatrout. Both seatrouts are less fecund than the Atlantic coast weakfish, and Atlantic croaker appear less fecund in the Gulf of Mexico than in the Middle Atlantic Bight at similar sizes. Longspine porgy are much less fecund than Atlantic coast red porgy due to their small size. Atlantic cutlassfish from the Gulf appear less fecund than those from Cuba.

Length, weight, and ovary weight are traditionally explored as predictors of fish fecundity (Bagenal 1967), and one or more of these factors usually explains much of the variation in fecundity estimates. For our data, ovary weight was the most reliable predictor of fecundity except in Atlantic cutlassfish. However, poor to moderate predictive capacities were found in most of our fecundity regressions. Potential sources of variation include: 1) ovaries which appeared ripe but were actually in prespawning condition or which had already released some or all of the ripe eggs, thus inflating the egg counts by including a greater number of small diameter eggs per unit weight of ovary; 2) ovaries collected across an extended spawning period (with one or more peaks in spawning activity) which would be influenced by seasonal changes in metabolic activity, and which would cause inaccurate counts on either side of peak gonadal development; or 3) violation of our assumptions of uniform egg development and no degeneration or resorption of eggs. An extended spawning period is characteristic of batch or repeat spawners (Nikolskii 1969) and, among the fishes we examined, only longspine porgy apparently have a short (1–2 month) spawning season. The queenfish, *Seriphus politus*, is a batch-spawning sciaenid which exhibits a 3–6 month spawning period (longer for larger females) that is characterized by a single peak in gonadal indices, a weekly spawning frequency, and a decline in egg size as the spawning season progresses (DeMartini and Fountain 1981). Such factors could have affected our regression analyses since ovaries used for fecundity estimation were collected in 4–6 months of the spawning seasons of each of our species except spot and longspine porgy. We note that other investigators have reported ovary weight as an excellent predictor of fecundity (r^2 = 0.89–0.98) in fishes such as Atlantic menhaden, *Brevoortia tyrannus* (Dietrich 1979), Atlantic croaker (Morse 1980), and yellow flounder, *Limanda ferruginea* (Howell and Kesler 1977), all of which have 3–6 month spawning periods. However, fecundity estimates in these studies were based on ovaries collected only during probable peak spawning over periods of 40, 12, and 2 days, respectively. Our sampling strategy may thus be partially responsible for the variation in fecundity. Finally, we do not know whether or not ovaries of our species exhibit uniform development, or degeneration or resorption of eggs, traits which apparently vary among species. For example, uniform egg development throughout the ovary is found in vermilion snapper, *Rhomboplites aurorubens* (Grimes and Huntsman 1980) but not in bluefin tuna, *Thunnus thynnus* (Baglin 1982). Degeneration and resorption of eggs have been seen in weakfish (Merriner 1976) but not in queenfish (DeMartini and Fountain 1981).

The more abundant fishes on the Gulf of Mexico continental shelf have been characterized by Chittenden and McEachran (1976) as small, short-lived species with high annual mortality rates. We have noted here that the seven dominant species also reproduce at or before Age I. Although they appear to have common life history strategies, there are differences in reproductive patterns relating to season, duration of spawning, and fecundity.

FOOD HABITS

Diets were analyzed by age, area, and time of day. Neither sand seatrout nor Atlantic cutlassfish, both piscivores, altered their diets in response to these factors. Only the spot diet appeared to be affected by time of capture (age and area had little effect), since polychaete consumption was higher at night and predation on small crustaceans was higher during the day. Age influenced the Atlantic croaker diet as fish moved from infaunal to large epifaunal prey with growth, and area had a similar effect on the feeding of longspine porgy. Age and area influenced the diets of silver seatrout and hardhead catfish. Older silver seatrout, particularly from the East Delta, ate more fishes and less shrimps than did younger, West Delta fish. Like Atlantic croaker, older hardhead catfish consumed more large epifauna and less infauna than did younger individuals. Polychaetes and crabs were more abundant in East Delta hardhead catfish stomachs than in West Delta stomachs, while the reverse was generally noted for stomatopods, shrimps, and fishes. The change in diet with age of the benthic feeding Atlantic croaker and hardhead catfish is likely related to the increase in mouth size which enables older (larger) fish to prey upon larger epifaunal organisms. Predation upon larger organisms was also seen in spot, but to a much lesser extent. The influence of area upon diets probably reflects differences in available prey on either side of the Mississippi Delta. To our knowledge, a comparative analysis of the abundance and composition of the benthic faunas of the East and West Delta continental shelves has not been made.

Given the diversity of potential prey organisms around the Mississippi Delta, it is important to note that only a few taxa regularly occurred in the diets. Among prey fishes, *Anchoa* and *Bregmaceros* were most frequently observed in stomachs of both epibenthic and benthic feeders. *Anchoa* spp. are abundant in estuaries (Christmas and Waller 1973) but are less often captured offshore (Chittenden and McEachran 1976; Ragan *et al.* 1978). *Bregmaceros* is common in the northern Gulf of Mexico but it is rarely caught except in plankton nets due to its small size and nocturnal migrations off the bottom (Dawson 1966). Perhaps some behavioral component or an underestimated abundance makes these two taxa such important prey. Only Atlantic croaker and hardhead catfish consumed crabs to any extent. Fourteen crab taxa were identified, and *Pinnixa*, xanthids, and pagurids were found most often. Xanthids and pagurids are common shallow water crabs (Bedinger 1981), but *Pinnixa* spp. have not been reported as such. Both benthic and epibenthic feeding fishes seemed to prefer the shrimps *Acetes* and *Trachypenaeus*. *Acetes* is a small, common planktonic shrimp (Franks, Christmas, Siler, Combs, Waller, and Burns 1972; Bedinger 1981) apparently easily preyed upon by various sizes of fish. Penaeid shrimps were often eaten, particularly by seatrouts, as representatives of six genera were identified. *Trachypenaeus* spp. are common on the continental shelf (Franks *et al.* 1972; Bedinger 1981) but usually less numerically abundant than commercial *Penaeus* spp. Yet here and elsewhere (Rogers 1977, Divita *et al.* 1983, Sheridan and Trimm 1983), it is reported that fish prey more often upon *Trachypenaeus* than upon *Penaeus*. One likely reason for this phenomenon is that *Trachypenaeus* is a much smaller shrimp than offshore *Penaeus* spp. In summer trawl catches off the Texas coast, Divita *et al.* (1983) found the average *Trachypenaeus* weighed 4–6 g and the average *Penaeus* *aztecus* weighed 10–37 g, while the associated fish fauna averaged 19–50 g. Concurrently, *Trachypenaeus* was found in 4.10% of the 7,374 fish stomachs examined while only 0.18% of the fish consumed *Penaeus*.

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